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Soubrane, Olivier ; de Rougemont, Olivier ; Kim, Ki-Hun ; Samstein, Benjamin ; Mamode, Nizam ; Boillot, Olivier ; Troisi, Roberto I ; Scatton, Olivier ; Cauchy, François ; Lee, Sung-Gyu ; Griesemer, Adam ; Ahmed, Zubir ; Clavien, Pierre-Alain ; Cherqui, Daniel

Abstract: OBJECTIVE: The aim of the study was to compare the short-term donor outcomes of laparoscopic left lateral sectionectomy (LLLS) for adult to child living donor liver transplantation (A-C LDLT) and laparoscopic donor nephrectomy (LDN). BACKGROUND: Although laparoscopy has become the standard approach in kidney donors, its use remains limited and controversial in LLS for A-C LDLT due to the lack of conclusive assessment of procedure-related morbidity. METHODS: From 2001 to 2014, 124 healthy donors undergoing laparoscopic LLLS for A-C LDLT at 5 tertiary referral centers in Europe, North America, and Asia, and 300 healthy donors undergoing LDN at 2 tertiary centers in Europe were retrospectively analyzed. The outcomes of LLLS were compared with those of LDN including the use of the comprehensive complication index (CCI). RESULTS: Although liver donors experienced significantly less overall (16.9% vs 31.7%, P = 0.002) and grade 1 to 2 (12.1% vs 24.7%, P = 0.004) complications than kidney donors, the rates of major complication (grade 3) were similar between the 2 groups. In both groups, donors experiencing postoperative complications had similar CCI (19.3 vs 21.9 for liver and kidney donors, respectively, P = 0.29). After propensity score analysis allowing for matching donors on age, sex, and body mass index, the postoperative outcomes remained comparable between the 2 groups. CONCLUSION: Laparoscopic LLS for A-C LDLT yields at least similar short-term donor outcomes as LDN. These results provide the first validation for a laparoscopic donor hepatectomy and suggest that the laparoscopic approach should be considered a new standard practice for retrieval of left lateral section liver grafts as it is for kidney donation.

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Laparoscopic Living Donor Left Lateral Sectionectomy: A New Standard Practice for Donor Hepatectomy

Olivier Soubrane, MD,† Olivier de Rougemont, MD,‡ Ki-Hun Kim, MD,§ Benjamin Samstein, MD,¶ Nizam Mamode, MD,|| Olivier Boillot, MD,** Roberto I. Troisi, MD,†† Olivier Scatton, MD, PhD,‡‡ François Cauchy, MD,*† Sung-Gyu Lee, MD,§ Adam Griesemer, MD,¶ Zubir Ahmed, MD,|| Pierre-Alain Clavien, MD, PhD, FACS (Hon),‡§§|||| and Daniel Cherqui, MD¶§§||||*

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Results: Although liver donors experienced significantly less overall (16.9% vs 31.7%, $P = 0.002$) and grade 1 to 2 (12.1% vs 24.7%, $P = 0.004$) complications than kidney donors, the rates of major complication ($\geq$ grade 3) were similar between the 2 groups. In both groups, donors experiencing postoperative complications had similar CCI (19.3 vs 21.9 for liver and kidney donors, respectively, $P = 0.29$). After propensity score analysis allowing for matching donors on age, sex, and body mass index, the postoperative outcomes remained comparable between the 2 groups.

Conclusion: Laparoscopic LLS for A-C LDLT yields at least similar short-term donor outcomes as LDN. These results provide the first validation for a laparoscopic donor hepatectomy and suggest that the laparoscopic approach should be considered a new standard practice for retrieval of left lateral section liver grafts as it is for kidney donation.

Keywords: kidney live donor, laparoscopy, liver live donor, liver transplantation, surgery complications

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From the *Department of HPB Surgery and Liver Transplant, Beaujon Hospital, Clichy, France; †University Denis Diderot, Paris, France; ‡Swiss HPB and Transplantation Center, Department of Surgery, University Hospital Zurich, Zurich, Switzerland; §Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea; ¶Center for Liver Disease and Transplantation, Department of Surgery, Columbia University Medical Center, New York, NY; ||Department of Transplantation, Guy's Hospital, London, UK; **Department of Liver Transplant, Hôpital Edouard Herriot, Lyon, France; ††Department of General and Hepatobiliary Surgery, Liver Transplantation Service, Ghent University Hospital and Medical School, Ghent, Belgium; ‡‡Department of Surgery, Hôpital La Pitié, University Pierre et Marie Curie, Paris, France; §§Centre Hépato-Biliaire, Hôpital Paul Brousse, Villejuif, France; and ||||University Paris Sud, Paris, France.

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Reprints: Olivier Soubrane, MD, Department of HPB Surgery and Liver Transplant, AP-HP, Beaujon Hospital, 100 Boulevard du Général Leclerc, 92110 Clichy, France. E-mail: olivier.soubrane@bjn.aphp.fr.

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Adult-to-child live donor liver transplantation (A-C LDLT) has shown similar or even better results than deceased donor liver transplantation in pediatric recipients.[1–4] In most cases, A-C LDLT uses left lateral section grafts. Laparoscopic left lateral sectionectomy (LLLS) has been first reported in 2002[5] but has remained limited to highly specialized centers, and controversial due to the lack of conclusive assessment of procedure morbidity.[6–8] We recently reported a larger cohort of laparoscopic donor hepatectomies including both LLS and left hepatectomies focusing on the feasibility and development of the laparoscopic technique in a single center.[9] This series, however, failed to validate the technique due to the absence of a control group. During the Second International Consensus Conference on laparoscopic liver resection held in Morioka, Japan, in October 2014,[10] a session was dedicated to laparoscopic donor hepatectomy (LDH). The Jury found no difference between open and laparoscopic surgery regarding donor safety, but the quality of evidence was considered low, not only because of the absence of randomized study but also the lack of convincing data on postoperative morbidity and a control group, and therefore, a call was made for further more conclusive comparative studies.[10]

Laparoscopic donor nephrectomy (LDN) has become standard practice in live kidney donors, as randomized studies and meta-analyses have demonstrated advantages of minimally invasive surgery, when compared with the open route.[11–14] This well-accepted technique has even contributed to a significant increase in kidney donation rate.[15]

After the Consensus Conference of Morioka,[10] a collaborative group decided to assess the outcome of LLLS for pediatric transplantation, comparing it with the widely accepted LDN using a modern tool of morbidity assessment, the comprehensive complication index (CCI),[16] based on the Clavien-Dindo classification of complications.[17] The aim of this retrospective study was to report the results of a multi-institutional series of LLLS for A-C LDLT and evaluate its short-term outcomes in reference to the LDN, a validated procedure considered standard practice in kidney donation.

METHODS

Study Design

The collaborative consortium included the following liver transplant centers: Paris, France (Cochin-St Antoine Hospital), Lyon, France (E. Herriot Hospital), New York, USA (Columbia Presbyterian Medical Center), Seoul, Korea (ASAN Medical Center), and Ghent, Belgium (Ghent University Hospital). We analyzed the data from living donors, who underwent LLLS from 2001 to 2014. The following donor data were obtained from prospectively maintained databases: age, sex, body mass index (BMI), American Society of Anesthesiology (ASA) score, need for conversion into laparotomy, surgery duration, estimated blood loss, allogeneic red blood cell transfusion, hospital stay duration,

number, and nature of postoperative complications according to the Clavien–Dindo (CD) classification.[17] Minor complications were defined as grade I to II, whereas major ones were defined as grade III to V complications.

The control group included kidney donors operated in 2 transplant centers in Zurich, Switzerland (University Hospital Zurich), and London, UK (Guy's Hospital) between 2009 and 2014. The donor data included age, sex, BMI, ASA score, need for conversion, surgery duration, hospital stay duration, and occurrence of postoperative complications according to the Clavien–Dindo system.

Live Donor Hepatectomy

All liver donors were healthy relatives, who had undergone complete preoperative work-up, including cardiac, pulmonary, and renal assessment, psychiatric evaluation, screening for infectious diseases, and coagulation disorders. Liver studies included ultrasound, computed tomographic scanner, and magnetic resonance imaging of the liver. Donors gave their informed consent and fulfilled local legal and administrative requirements. The pure laparoscopic technique was previously described by some of us.[5–9] In brief, the liver donor was in the supine position with his legs apart. Five trocars were used in the majority of cases with a CO_2 pneumoperitoneum maintained at 12 mm Hg. The left lateral section was mobilized and the left hepatic artery and left portal vein were dissected and taped. Liver transection was performed on the right side of the umbilical fissure using a combination of ultrasonic dissector, bipolar coagulation, harmonic scalpel, vessels sealing devices, and clips according to the surgeon's preferences. After reaching the hilar plate, the left bile duct(s) was cut and the stump on the donor side was either clipped or sutured. Cholecystectomy and intraoperative cholangiography were not routinely performed. At the end of parenchymal section, the left hepatic vein was dissected free and taped. The vessels were then closed using either clips or vascular staplers and the liver graft was placed in a large bag, externalized through a suprapubic incision, weighed, and immediately flushed with cold preservation solution. Fascia was closed for incisions at least 1 cm and skin closed with subcutaneous sutures.

After surgery, donors received prophylactic doses of low-molecular-weight heparin for the prevention of deep vein thrombosis for 1 month, as well as proton pump inhibitors for prevention of peptic ulcers.

Live Donor Nephrectomy

The technique has been described previously elsewhere.[18] In brief, the kidney donor was in the lateral decubitus position. The access was either transperitoneal or retroperitoneal according to surgeon's choice, using either a hand-assisted or full laparoscopic technique. The optics and camera as well as 2 to 4 additional trocars were placed under visual control. The technique included the mobilization of the kidney, identification of the ureter, and dissection of the renal vein and artery. The ureter was then divided using a secured clip. The artery and veins were transected using a linear vascular stapler. The kidney was placed in a bag and retrieved either through a separate incision or a hand port. Fascia was closed for incisions at least 1 cm and skin closed with subcutaneous sutures.

Postoperative Outcomes

The primary outcome of this retrospective study was the CCI, which is a score designed and developed to take into consideration all complications occurring after a surgical procedure, and based on the CD classification of complications.[17] The mathematical formula and validation of this score have previously been published.[16,19] In the present study, the CCI was calculated for the whole donor cohort using the following website: http://www.assessurgery.com/.

Statistical Analysis

Quantitative variables were expressed as mean ($\pm$1 standard deviation) or as median (range) where appropriate. Qualitative variables were expressed as frequencies (percentages). A Student *t* test or Mann-Whitney *U* test was used for intergroup comparisons of quantitative variables where appropriate, whereas a χ^2 test or Fisher's exact test was used to compare categorical data. Regarding the comparison of the postoperative outcomes between laparoscopic liver and kidney donors, a first analysis was performed considering the overall study population. However, given the noncomparability of the groups, a second comparison was performed using propensity score matching. In this setting, a logistic regression model was used and propensity score adjustment was performed on the following preoperative characteristics: sex, age less than 40 years, and obesity as defined by a BMI more than 28 kg/m^2. Using these propensity scores, LDLT patients were randomly matched to LDKT patients using a 1:1 interval matching method. Thereafter, the groups were compared for examining covariate balance and whether there were statistical differences in baseline covariates between groups or not. Finally, after assuring the comparability of the groups, comparison of both CCI and postoperative complications rates between the 2 groups was performed using a Mann-Whitney *U* test for intergroup comparisons of quantitative variables and the χ^2 test or Fisher's exact test as appropriate for comparison of categorical data. A *P* value of less than 0.05 was considered significant. All statistical analyses were performed with SPSS version 20.0 (SPSS Inc., IBM Corp, Armonk, NY).

RESULTS

Liver Donor Characteristics

A total of 124 live liver donors, including 64 males, underwent LLLS. Their characteristics are given in Table 1. Donors were mostly father (n = 63) or mother (n = 55) of the recipient, but in 6 cases, they were aunt (n = 2), uncle (n = 2), older sister (n = 1), or family friend (n = 1). Conversion to open surgery was necessary in 4 liver donors due to left portal vein injury (n = 1), failure to recognize the left portal vein (n = 1), and failure to progress during transection (n = 2). No liver donor received allogeneic red blood cell transfusion.

Liver Donors Complications

No donor died. Twenty-one complications (17.9%) occurred, including 9 grade I, 6 grade II, and 6 grade III. These complications are detailed in Table 2.

Four donors (3%) required reoperation. Two of them had bile leak due to metal clip dislodgement either from the stump of the left bile duct (n = 1) or segment I bile duct (n = 1). Both of them were operated by redo laparoscopy with suture of the bile duct opening and they had uneventful postoperative course. One donor had suprapubic hematoma that required surgical drainage. The last complication was hematuria and pelvic pain. Cystoscopy showed a transfixing suture in the bladder wall resulting from closure of the suprapubic incision. The suture was removed during the same cystoscopic procedure with no further complications.

Kidney Donors Complications

No donor died. Ninety-five complications (31.7%) occurred, including 22 grade I, 52 grade II, 5 grade IIIa, and 16 grade IIIb. These complications are detailed in Table 3.

Liver and Kidney Donors Comparative Complications

Comparative postoperative outcomes of liver and kidney donors are given in Table 4. Raw analysis showed a significantly lower number of minor complications in liver donors, as compared

TABLE 1. Characteristics of 124 Liver Donors and Left Lateral Section Grafts

Age, median (range), years	33.3 (17–57)
Sex, n (%)	
Male	64 (51.6)
Female	60 (48.4)
BMI, median (range), kg/m^2	23.6 (16–35.5)
ASA score	
1	112 (90)
2	12 (10)
3–6	0
Relationship to recipient, n (%)	
Father	63 (50)
Mother	55 (45)
Other	6 (5)
Surgery duration, median (range), min	308 (180–555)
Conversion to open approach, n (%)	5 (4)
Estimated blood loss, median (range), cc	50 (10–500)
Liver graft weight, median (range), gm	250 (118–450)
Number of arterial branches, n (%)	
1	116 (93)
2	8 (7)
Number of bile ducts, n (%)	
1	103 (83)
2	21 (17)
Number of cases per center, n (%)	
Paris, France	64 (52)
Seoul, Korea	25 (20)
New York, United States	16 (13)
Lyon, France	13 (10)
Ghent, Belgium	6 (5)

ASA indicates American Society of Anesthesiologists; BMI, body mass index.

with kidney donors, but the rates of major complications were not significantly different between the 2 groups. A comparable CCI was observed between liver and kidney donors with complications. The same comparison was performed after propensity score analysis with matching on age, sex, and BMI. The liver and kidney groups of 58 donors each were compared and data are given in Table 5. CCI remained similar between liver and kidney donors with complications after matching.

Results in Children Recipients

All liver grafts were transplanted and no primary nonfunction occurred. The 90-day mortality rate was 3.1%: 4 recipients died from sepsis. Five children required retransplant because of arterial thrombosis (n = 4) or portal vein thrombosis (n = 1).

DISCUSSION

The present study is the first comparative assessment of morbidity following laparoscopic living donor left lateral sectionectomy for pediatric liver transplantation. We chose LDN as a control group, as it is the most commonly performed live donor surgery and is considered the gold standard in most centers.[12] Analysis of postoperative outcomes of 124 LLLS for A-C LDLT showed an overall morbidity lower than those observed after LDN. Morbidity consisted mainly in minor complications (grade 1 to 2), while the rates of major complications were very low (<10%) and identical in both groups. The CCI, used as the primary end point, has the advantage to take into account all complications in a given patient.[16] It was lower in the liver donors but identical in both groups when considering only patients with complications. These results were confirmed after matching for age, sex, and BMI. We believe our study demonstrates that LLLS for A-C LDLT is at least as safe as LDN.

TABLE 2. Details of Postoperative Complications in Liver Donors

Clavien–Dindo Classification	Type of Complication	Number of Patients
Grade 1	Suprapubic hematoma	3
	Gastric ulcer	1
	Occipital alopecia	1
	Pneumothorax without drainage	1
	Wound infection	1
	Ileus	1
	Arm neuropraxia	1
Grade 2	Gastroparesia	2
	Pulmonary infection	1
	Segment IV infarction	1
	Pneumothorax without drainage	1
	Right anterior bile duct stenosis	1
Grade 3		
Grade 3a	Fluid collection	1
	Bladder injury	1*
Grade 3b	Suprapubic hematoma	1*
	Bile leakage	3†
Grade 4–5	—	0

*Requiring reoperation.
†Two patients required reoperation and 1 patient was treated using endoscopic retrograde cholangiography with stenting.

LDN is considered a straightforward procedure, as 1 whole kidney is removed with its own pedicle and ureter, and without the need for parenchymal transection. By contrast, LDH requires recovery of partial vascular and biliary pedicles as well as parenchymal transection. The complexity of the procedure, the perceived risk of donor complications, and the relatively small number of indications for pediatric liver transplantation have slowed down the development of the laparoscopic approach. These issues raised persisting concerns about donor safety and graft integrity, and prevented the laparoscopic approach to be considered a validated alternative to the open procedure.

Since the first report in 2002 (5), LDH has remained limited to few centers, most of which contributed to this study. In a recent

TABLE 3. Details of Postoperative Complications in Kidney Donors

Clavien-Dindo Classification	Type of Complication	Number of Patients
Grade 1	Wound hematoma/seroma	5
	Prolonged nausea	5
	Pain	1
	Diarrhea	2
	Postoperative ileus	2
	Testicular pain	7
Grade 2	Surgical site infection	22
	Pulmonary infection	10
	Urinary tract infection	11
	New hypertensive treatment	7
	Blood transfusion	1
	Erythema	1
Grade 3		
Grade 3a	Fluid collection	5
Grade 3b	Wash out	13
	Appendectomy	2
	Splenectomy	1
Grade 4–5	—	0

TABLE 4. Characteristics and Postoperative Outcomes of Liver and Kidney Donors

	Liver Donors (n = 124)	Kidney Donors (n = 300)	*P*
Sex male, n (%)	64 (51.6)	141 (47.0)	0.387
Age, median (range), years	33.3 (17–57)	47.6 (18–76)	<0.001
BMI, median (range), kg/m^2	23.6 (16–35.5)	26.0 (16.8–36.3)	<0.001
Hypertension, n (%)	1 (0.8)	36 (12)	<0.001
ASA score >1, n (%)	12 (9.7)	93 (31.0)	<0.001
Conversion to open surgery, n (%)	5 (4.0)	1 (0.3)	0.003
Surgery duration, median (range), min	308 (180–555)	177 (64–406)	<0.001
Complications, n (%)	21 (16.9)	95 (31.7)	0.002
Minor complications	15 (12.1)	74 (24.7)	0.004
Major complications	6 (4.8)	21 (7.0)	0.407
CCI all patients	3.3 (0–33.7)	6.9 (0.0–78.0)	0.002
CCI patients with complications	19.3 (8.7–33.7)	21.9 (8.7–78.0)	0.290
Hospital stay, median (range), days	6.3 (2–18)	5.6 (2–23)	0.010

ASA indicates American Society of Anaesthesiologists; BMI, body mass index; CCI, comprehensive complication index.

publication, we reported the results of 70 cases and described the development of the laparoscopic technique from the feasibility in the first cases to the development of a program in a single center.[9] This study included LLLS and some left hepatectomies for adult recipients. The major limitation of this series was the absence of a control group, explaining why the Jury of the Morioka Consensus Conference considered the level of evidence as low, and called for more robust data about short and long-term outcomes. This prompted us to conduct the current study aiming at benchmark comparison between LDH from 5 institutions and LDN.

Various approaches to LDN (open, laparoscopic, and hand-assisted) are considered standard practice.[12] The laparoscopic technique is, however, the recommended technique because it is associated with decreased blood loss, less postoperative pain, and shorter length of stay in hospital than after open technique, as shown in meta-analyses of randomized studies.[13,14]

After 2 consensus conferences, it is now well-accepted that laparoscopic minor liver resections for tumors are safe and reproducible.[10,20] Despite the absence of randomized trial, the high number of published cases and the encouraging results associated with the laparoscopic versus the open approach on many endpoints have convinced the independent jury of the second Consensus conference about the potential advantages of laparoscopy. Several meta-analyses of case-matched studies have shown that laparoscopic liver resection for tumors exhibit several advantages over open procedures, such as reduced blood loss, decreased morbidity, and shorter recovery times.[21,22] In a recent publication, a systematic review with meta-analysis of LDH found no difference in donor safety between minimally invasive and open approaches, and found lower blood loss associated with LLLS for pediatric transplant.[23] This decreased blood loss is of special interest in live donors, as it has been shown that blood loss is associated with an increase in overall morbidity.[24]

Accurate figures on perioperative mortality are difficult to assess in the absence of currently available international registry for laparoscopic liver surgery, and the low number of LDH procedures performed to date. For live kidney donation, the 90-day mortality rate was 3.1 per 10,000 donors in the largest national registry of more than 80,000 donors reported from the USA.[25] A few reports have tried to estimate the mortality rates associated with open surgery for liver donation through international investigations and systematic reviews of published fatalities.[26,27] The estimated mortality rates ranged between 0.05% and 1%, with a possible actual rate of 0.1% to 0.5%. The vast majority of fatalities resulted from right hemiliver donation suggesting that the risk of death correlates with the amount of resected hepatic tissue, and thus is significantly higher for right hemiliver donation than for limited left lateral sectionectomy.

TABLE 5. Characteristics and Postoperative Outcomes of Liver and Kidney Donors After Propensity Score Matching

	Liver Donors (n = 58)	Kidney Donors (n = 58)	*P*
Male sex, n (%)	20 (34.5)	20 (34.5)	*
Age, mean (range) years	31.7 (18–39.6)	31.9 (18.7–39.9)	0.748
Age <40 years, n (%)	58 (100)	58 (100)	*
BMI, median (range) kg/m^2	23.4 (16.0–35.5)	23.9 (16.9–35.2)	0.741
BMI <28, n (%)	43 (74.1)	43 (74.1)	*
ASA <2, n (%)	58 (100)	58 (100)	1.000
Hypertension, n (%)	1 (1.7)	2 (3.4)	0.558
Conversion to open surgery, n (%)	2 (3.4)	1 (1.7)	0.558
Surgery duration, median (range) min	320 (180–555)	176 (80–376)	<0.001
Complication, n (%)	7 (12.1)	22 (37.9)	0.001
Minor complication	4 (6.9)	14 (24.1)	0.001
Major complication	3 (5.2)	8 (13.8)	0.113
CCI all patients, median (range)	2.1 (0.0–33.7)	9.4 (0.0–33.7)	<0.001
CCI patients with complication, median (range)	19.9 (8.7–33.7)	23.9 (8.7–33.7)	0.357
Hospital stay, median (range), days	6.5 (2–14)	5.4 (2–11)	0.019

*Variables used for propensity score matching.
ASA indicates American Society of Anaesthesiologists; BMI, body mass index; CCI, comprehensive complication index.

In the current international series of LLLS, we observed zero mortality but an overall morbidity rate of 17%, including 5% of major complications. These figures are comparable to those described in previous reports after open surgery.[28] Two types of complications from our series need, however, to be highlighted. First, 4 patients developed biliary complications, representing a 3% incidence, which is in the usual range reported in open live donor hepatectomy.[24,28] Two were major ones due to a dislodged clip and required redo laparoscopy. These 2 cases occurred early in the most experienced center and bile leaks were no longer observed after the use of secured clips or stitches. Second, 5 (4%) complications were related to the Pfannenstiel incision: 4 hematomas, including 1 requiring drainage, and 1 bladder trauma due to suture transfixion during abdominal wall closure. These serious complications emphasize the need for special attention to extraction incisions in laparoscopic surgery. Again, all 4 occurred early in the experience and have not been observed since.

Recipient and graft outcomes were not the purpose of this study, but as summarized in Table 1, the number of grafts arteries and bile ducts were in the normal range of open series and patient and graft survival were previously studied and found identical to those reported with open surgery.[7,9]

This study has several limitations. First, comparing morbidity of 2 different entities of surgery might seem inappropriate. However, this was a deliberate choice aiming at benchmarking LDH by comparison with the well-accepted LDN. Our study was made possible by the careful prospective recording of all adverse events, including minor morbidity, allowing calculation of the CCI in both liver and kidney donors, making it a solid comparison. A second limitation is that liver cases originated from highly specialized centers. However, the multicentric participation from various countries demonstrates the reproducibility of the procedure in the hands of trained surgeons. The final limitation is the retrospective nature of the study. Although a randomized controlled trial comparing open versus LLLS in live donors should be performed, the low number of pediatric LDLT prevents the feasibility of a meaningful study. In the current study, several facts contribute to validate the procedure: the large number of cases showing at least identical safety of the LDH with standard LDN, the multicentric participation from various countries, and finally the use of a very sensitive marker of complications, the CCI, which has already demonstrated to strengthen comparisons and increase sensitivity.[19,29]

In conclusion, this study provides the first validation of LDH and suggests that laparoscopy, along with the open approach, should become, similarly to LDN, a standard practice for retrieval of left lateral section liver grafts in live donors. More data about the short and long-term outcomes in both donor and recipient should be obtained in the future through international registries to better determine the benefit/risk ratio of this laparoscopic procedure.

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DISCUSSANTS

J.C. García-Valdecasas Salgado (Barcelona, Spain):

Thank you very much for giving me the opportunity to review this article.

This is an interesting study, although retrospectively it has the value to have been performed by highly recognized surgical groups. I have to recognize that it has taken me time to understand the rationale of the study. The authors recognized that even though it is lacking an adequate control group, they decide to compare retrospectively 2 totally different procedures by using the recently described CCI. By doing so, the authors are able to show that the risk of LLLS is similar to a well-established and accepted standard of care procedure such as LDN. The authors conclude that as this is the case, LLLS should be considered the standard of care for adult to child living donor liver transplantation. The authors have shown that LLLS is a safe procedure in the hands of highly selective surgical groups and may be considered a very good alternative to the open one. I can only congratulate the group for such outstanding results.

I have some questions: As a surgeon, I am very interested to know how the trocars are placed as well as which are the most frequent positions that are used by the various groups. We often watch beautiful videos showing the hepatic veins as well as what seems to be an easy approach to the hilum. However, we keep forgetting that the positioning of trocars are most important in order to have such good views.

Was the donor heparinized right before retrieving the organ? How long did it take from vascular clamping to graft abdominal extraction (median, range)?

I understand that the advantage of using CCI allows us to compare a wide range of complications, no matter the type of procedure. As the authors assumed in the text, LLLS is a procedure with a significant increased complexity when compared with LDN. At the same time, the authors suggest the importance of blood loss during the procedure as a major factor in the incidence of complications (the reason of the 4 conversions). It is clear that the risk of bleeding during LDN is significantly lower. The way we perform liver parenchyma transection is still a matter of controversy. I would like to know the author's opinion about the current systems of vessels sealing and transection devices. Are they good enough, or should we look for a better system in order to be able to consider a laparoscopic approach of the liver as the standard of care?

Response From O. Soubrane (Clichy, France):

Thank you very much. Your first question concerned trocar placement. For this part of the liver, which is the left side, it is quite easy to mobilize and see the liver with this approach. It is a very standard position with the optics on the midline, probably just above the umbilicus and, with the rule of triangulation, 2 operative trocars, 1 on each side, and a fourth and fifth trocar below the sternum and in the right flank, respectively. This is very usual and probably there is no big variation among the teams about these trocar positions.

Your second question was about heparin. Unfortunately, this point was not recorded in the whole database, but I can answer for the French part of this series. We did not use heparin in the donor before clamping. We are not very confident when it comes to the use of heparin during hepatectomy, but we probably should think about it in the future.

Your third question was about the time necessary to remove the liver graft and you refer to the risk of warm ischemia. The median warm ischemic time was 8 minutes and the longest time was 12 minutes. I think this is reasonable and probably does not exceed the warm ischemia time observed in open surgery. The trocar with the big bag is already in the abdomen at the time of clamping. This is going quickly.

Your fourth question is about the risk of bleeding. We now have more and more devices allowing for a good control of bleeding and we think that probably the blood loss in laparoscopic liver surgery is lower and lower. I am not saying that there is no risk of hemorrhage, but no patient was transfused in this large multicentric series. The low level of blood loss is explained by the pneumoperitoneum pressure and the low CVP. Other factors such as the position specific for laparoscopic surgery with the head up tilt and the reverse Trendelenburg may also play a role.

Regarding the devices used to cut the liver, this was a topic covered by the experts during the last consensus conference last October in Japan. Most teams use cautery devices to open the superficial part of the liver followed by the ultrasonic dissector with aspiration and bipolar coagulation. This kind of device is more and more sophisticated and you can change the parameters of the program according to the characteristics of the liver you are cutting. When you have arrived in the posterior part or near the big hepatic veins, you may change the program with a softer intensity of ultrasounds.

H. Bismuth (Paris, France):

Thank you, it is a very interesting study and I have nothing to say about the study design. My question is more in the forefront of your work. Some years ago, Xavier Rogers showed us here that removing the left lobe of a cadaveric graft has no negative effect at all on the remaining graft to be used for an adult recipient. My question is: Why do you use a living donor when you can use a cadaveric graft to be split into 2 transplants for a child and an adult with the same results? Although this cannot be used in all cases, there are enough good livers for the need of the pediatric population.

Response From O. Soubrane (Clichy, France):

Thank you Professor Bismuth for your important point. There are, however, several reasons why we still need living donors. This is a situation very different than in the adult population. First, even though we may take advantage of the split procedure, you know that the deceased donors are not the same as 20 years ago. We have much older donors and marginal livers such as steatotic grafts, which cannot be used for children or infants.

Second, there is a strong demand from many families and parents. A young mother and a young father are sometimes extremely willing to give their own liver to their child. We must take this into consideration. At last, there are some convincing data showing that the best results, including survival rates, are obtained using a liver graft from a live donor even considering that some teams are still reluctant because the vessels are short with a higher risk of technical complication. This is why it is difficult to ignore this approach. We have gathered for this study case from all over the world to reach a significant number. Pediatric liver transplantation represents grossly 5% of liver transplants all over the world. Although this might seem to be a small figure, it still represents many cases for which living donation is important.

N. Senninger (Münster, Germany):

First of all, I would like to express my applause to your surgical skills because doing this operation in a laparoscopic way requires enormous expertise and obviously you have it. It is, however, not a pure laparoscopic procedure, although you are doing hepatic hilar dissection laparoscopically because you have to retrieve the organ so there is an incision anyway. It is a hybrid procedure, just to make this clear. I am in a center where we have tested both approaches for living kidney transplantation, and we, and many others, still practice the open approach. So, laparoscopic living kidney harvesting to me cannot be called a gold standard. The lateral–anterior, purely retroperitoneal incision takes just 60 to 70 minutes time for retrieval, the first warm ischemia time takes just 20 seconds as compared to 3 to 4 minutes in laparoscopic

procedures. We have a 100% function rate of the kidneys in the first year. This cannot be so bad! So, we are not changing our program. My major concern is that you are comparing 2 operations that are not comparable. The main comment is that avoiding the event of a donor death, which is a sentinel event, cannot be called an advantage, as it should never ever happen. At the moment, I'm waiting for the scientific proof that we all should do the living related left liver resection in a laparoscopic way. I am not going to change it according to your data so far.

Response From O. Soubrane (Clichy, France):

I think, as you said, we compared healthy donors even though they were not giving the same organ. It was impossible to organize any other type of comparison, especially no randomized study was thinkable in this setting. The main point of this study is that we could show using new tools in outcome research that laparoscopic living donor left sectionectomy is safer than laparoscopic living donor nephrectomy, and thus, we would suggest that the laparoscopic approach for living donor left sectionectomy becomes a standard of care.